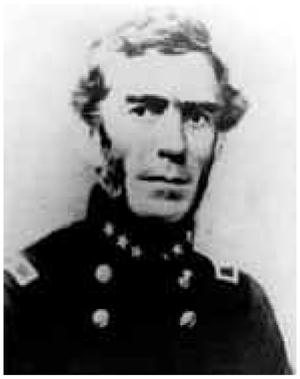
U.S. Army Fort Bragg
Home of the XVIII
Airborne Corps



C.S.A. Gen. Braxton Bragg

"Iron Mike"

Symbol of US Fighting Airborne Trooper

Ft. Bragg PEM Fuel Cell Demonstration Program
LOGANEnergy Corporation
Initial Project Description
September 5, 2002

Executive Summary

In October 2001, LOGANEnergy Corporation received a contract award from the US Army Corps of Engineers, Construction Engineering Research Lab to test and evaluate Proton Exchange Membrane (PEM) Fuel Cells at several DOD sites. Ft. Bragg Army Base in Fayetteville, NC was one of the sites awarded to LOGAN and this installation is in its final phase. The initial start-up should take place by the end of September, 2002.

The demonstration site will be located at the base Environmental Center. It will host a 5kW 120/240 vac, SU-1 PEM technology demonstration unit manufactured by Plug Power Corporation, Latham, NY. The unit will be installed in a grid parallel / grid synchronized configuration and operate nominally at 2.5kW during the one-year demonstration test program. The unit will be instrumented with an external watt meter and a gas flow meter. A phone line will be connected to a data modem within the power plant to callout to Plug Power with alarms or events requiring service and attention.

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Introduction

Fuel Cells convert the chemical energy of a fuel into useable electric and thermal energy without an intermediate combustion or mechanical process. In that respect, they are similar to batteries. However, unlike batteries, fuel cells oxidize externally supplied fuel and therefore do not need recharging. Ever since National Aeronautics and Space Administration (NASA) adopted fuel cell power for the Apollo Space program, American industry has been fascinated by the prospects for their use on earth as well.

When integrated with a fuel processor and a solid-state power conditioner, the power system becomes one that produces clean, quiet and reliable electric power and heat. Several manufacturers are currently hard at work to translate the basic technology into consumer products. As advances in PEM technology and mass production converge to introduce competitively costs systems into the marketplace, many are betting that small scale fuel cell generators will soon be ready to tackle thousands of residential and small scale commercial power applications. These new appliances will be packaged energy systems providing both heat and electricity that will be able to operate with or without the local utility grid.

Until recently, however, the promise of fuel cell technology has been slow to advance beyond a narrow beachhead commonly referred to as the "early adopter" marketplace. Broader market appeal has been constrained by fits, false starts and premature expectations raised by eager manufacturers; but also high prices, skepticism, and not a little resistance by parochial interests have all restricted the opportunity. Notwithstanding, during the decade of the 1990s, the UTC PC25C Fuel Cell program, largely assisted by a significant investment by DOD, gradually established a solid record of achievement and customer satisfaction at numerous US locations and around the world. Installations sites included military hospitals, commercial buildings, banks, food processing facilities, data processing centers, police stations, and airports.

While many of these "early adopters" hosted pure technology demonstration projects, the industry gained valuable experience and knowledge because of them. More recently, however, customers have warmed to the proposition that fuel cells have real performance advantages in various combined heat and critical power applications (CHP). Perhaps their attitudes and business practices may be adjusting to accommodate an uncertain energy landscape. Clearly, many energy providers are scrambling to maintain their market base, others are floundering, and still others are stalking new opportunity. Nevertheless, they are all discovering that informed consumers have gained new leverage through the power of choice. Increasingly, newspaper articles, periodicals and other media outlets are scoring direct hits with stories about fuel cells. Policy makers are out front raising expectations of a cleaner highly efficient fuel cell / hydrogen based economy of the future. The signals are clear. Initiative and momentum are driving a rapidly maturing fuel cell industry.

Certainly one reason is because fuel cell technology represents, perhaps, the most exciting and innovative development in the energy industry today. In some ways the technology is maturing more rapidly and markets are developing more quickly than the supporting infrastructure, codes and standards are able to accommodate. However, as technology demonstrations increasingly give way to CHP fuel cell installations that provide practical solutions to demanding consumer requirements, such roadblocks should get resolved as consumer and utility interests find common ground. For example, in most applications, large-scale fuel cell installations may off-load significant power resources during critical grid demand intervals, serving utility interests, while providing "hot" back-up for mission essential loads in commercial and even residential applications. Additionally, they may also provide thermal Btus for heating and cooling loads- demonstrating the dual benefits of enhancing grid stability and promoting energy conservation.

At the small scale and residential end of the fuel cell spectrum, the opportunity is just as promising for the rapid expansion of distributed power generation. Conceivably, thousands of 3kW to 5kW CHP fuel cells in homes and small businesses across the country could within several years displace hundreds of MWhs of electricity and millions of thermal Btus with clean, efficient and reliable energy service. If this occurs, it could have a dramatic impact on both the energy industry, and on the nation's economy and security. Consumers, not utilities, could begin displacing environmentally disruptive generation methods, thereby forcing changes in the industry. As providers of grid resources, they may one day collectively enhance grid stability in many areas, boosting efficiency and conservation norms, and having a decided impact on the evolution of national energy policy.

Against this backdrop, the US Army Corps of Engineers, Construction Engineering Research Lab (CERL) has contracted with LOGANEnergy Corporation to engage a progressive fuel cell energy strategy to inform future DOD policy and planning. Broadly speaking, this engagement directs LOGAN to purchase and install residential and small-scale fuel cell power plants, and then test and evaluate their performance in widespread applications at selected military installations. Three seemingly incongruous events make this program very timely. They are (a) the complexities and perplexities of utility deregulation juxtaposed with, (b) base utility privatization programs, and (c) the nascent interest in distributed generation / CHP technologies that promise more efficient utilization of resources.

If the fuel cell industry appeared very much ahead of a languid power market in the recent past, today those markets are in comparative turmoil. Prices and availability, in some cases, are volatile and beyond the comprehension of energy managers and consumers alike. Consumers who are seeking innovative and efficient energy solutions for greater comfort, convenience and reliability are adding a new urgency. If the fuel cell industry can capitalize on these conditions, it will have a rich market opportunity, but it will have to deliver energy services and benefits that are immediate, site specific, cost effective, energy efficient, and certifiably green!

In order to test and evaluate the state of PEM fuel cell technology against these challenges, LOGANEnergy Corporation will demonstrate over the course of a year a PEM small scale fuel cell at Ft Bragg, NC. The project will be guided by an operations plan that will direct the installation, testing, evaluation and reporting on the performance of the unit. The objectives of the plan include;

1. Evaluating installation methods in order to help standardize safe and cost effective installation practices,

2. Evaluating "out of the box" reliability and interoperability with existing facility electrical and mechanical systems / infrastructure,

3. Evaluating actual PEM operating characteristics as compared to manufacturer representations,

4. Measuring the cost of operating a PEM unit under real market conditions,

5. Measuring, collecting and analyzing operating data including, total load hours, availability, kW production, fuel consumption, water consumption, forced outages, serviceability, and manufacturer's support.

6. Introducing PEM technology, power distribution and energy efficiency to DOD and local stakeholders in the community.

The project will be led by LOGANEnergy and supported by energy professionals within the fuel cell manufacturing and the fuel cell application/ service industry, including Plug Power and Energy Signature Associates.

Ft. Bragg Site Selection

LOGAN and CERL personnel met at FT Bragg in mid March to discuss the demonstration project with the base facilities manager, Georges Dib. After discussing the optimum fuel cell location and the need for easy access to natural gas, water and an electrical connection, Mr. Dib led the party on a tour of the proposed site. Initially he indicated the preferred site was to be on a traffic island adjacent to the mechanical room serving the Ft Bragg Environmental Center; depicted in Figure 1 below.

Figure 1. Initial fuel cell site.

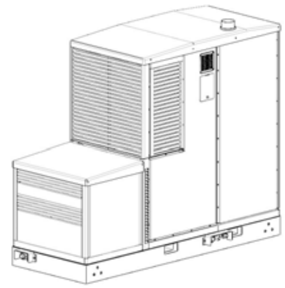
This site met all of the stipulated requirements. Natural gas was conveniently located against the building as depicted at left; and the mechanical room was immediately accessible through the double doors in the right background; housing electrical panels to make the fuel cell connection, and water source for the PEM unit.

In July 2002, Mr. Dib advised LOGAN that the fuel cell site had to be relocated since the preferred site overlay utility lines requiring accessibility at all times. After reviewing the alternatives, Mike Harvell of LOGANEnergy, and Mr. Dib determined that the fuel cell could be relocated to the other side of the building without forfeiting the advantages of the initial site. A photo of the actual fuel cell installation is depicted in Figure 2.

To accommodate the Plug unit, a small tree similar to the one behind the fuel cell had to be removed. The ground was excavated approximately six inches to provide a sub base of granite crush. Twelve inch pavers were laid over the crush to match the unit's foot print, and then framed with a 2" X 6" treated pine border. Access to the Environmental Building's mechanical room is through the red door in the left background.

Figure 2. Plug Power SU-1 PEM Fuel Cell, S/N SU01B0 000000002.

SU-1 Product Specifications



Stationary Unit 1 (SU1) is a 5kWAC on-site power generation system fueled by natural gas. Designed to be connected to the existing power grid, SU1 is a clean and efficient source of power.

Specifications

Physical	Size (L X W X H):	84½ X 32-in. X 68□-in.
Performance	Power rating:	5kW continuous
	Power set points:	2.5kW, 4kW, 5kW
	Voltage:	120/240 VAC @ 60Hz
	Power Quality:	IEEE 519
	Emissions:	NOX < 5ppm
		SO_X < 1ppm
		Noise < 70 dBa @ 1m
Operating Conditions	Temperature:	0 to 104°F
	Elevation:	0 to 750 ft
	Installation:	Outdoor
	Electrical Connection:	Grid Parallel
	Fuel:	Natural Gas
Certifications	Power Generation:	CSA International
	Power Conditioning:	UL
	Electromagnetic Compliance:	FCC Class B
Dimensions		
Length		84 in.
Width		32 in.
Height		68¼ in.
Operating Requirements		
	Fuel Type	Natural Gas
	Temperature	0 to 104 °F
Outputs		
	Power Output	5kW
	Voltage	120/240 VAC @ 60Hz
	Noise	< 70 dBA@ 1 m
Certifications		
	CSA International	Fuel Cell System
	UL	Power Conditioning Module

Figure 3. Plug Power Fuel Cell System.

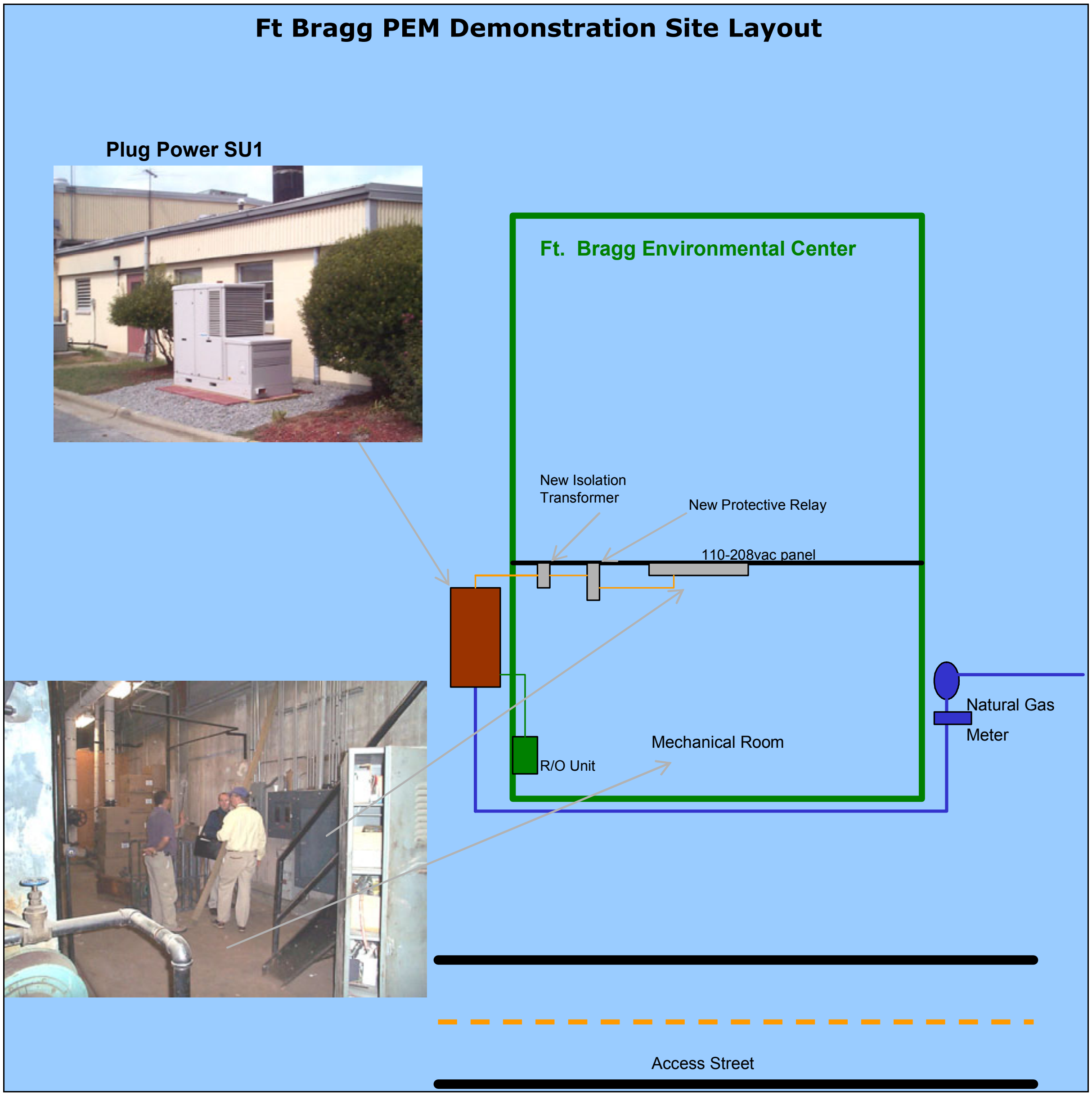


Figure 4. Fort Bragg Demonstration Site Layout.

Installation Application

Figure 3, above, lists the specifications of the Plug Power SU-1 PEM technology demonstration fuel cell unit for this installation. Figure 4, above, diagrams the location of the fuel cell pad in relationship to the utility interfaces including, power and water in the adjacent mechanical room, and natural gas on the opposite side of the building. The natural gas piping run is approximately 50 ft, the R/O water piping run is approximately 25 ft, and the electrical conduit run is approximately 25 ft.

The SU-1 inverter has a power output of 120/240 VAC at 60 Hz. However, the distribution panel in the mechanical room has connected loads at 110/208 VAC. In order to accommodate the step down in voltage, and prevent islanding of the fuel cell during grid failures, an isolation transformer and a grid protective relay will be installed between the fuel cell and the load 110/208 load panel indicated in Figure 4.

Gas will be supplied from a gas meter on the opposite side of the Environmental Center as indicated in Figure 4. A regulator will be installed at the fuel cell gas inlet to maintain the correct operating pressure.

A Plug Power supplied Reverse Osmosis water filtration system will be installed in the mechanical room to provide filtered process water to the power plant. Water will be piped to the fuel cell as indicated in Figure 4 above, and a heat strip will wrap the piping to prevent freezing.

A phone line will be provided to the fuel cell modem to establish communications with Plug Power and LOGAN customer support functions.

No construction permits were required to install this site.

Prior to starting the unit the items covered in Figure 5, below, will be completed. Then, once the unit has started, the unit will be tested and monitored in accordance with the factory recommended procedures listed in Figure 6, below.

Service incidents and facility calls will be reported on the sample Service Call Report form listed below (Figure 7).

An Economic Analysis of the Ft Bragg RESSDEM project appears in Figure 8.

Table 1. Installation Check List.

Task	Sign	Date	Time(Hrs)
Batteries Installed			
Stack Installed			
Stack Coolant Installed			
Air Purged from Stack Coolant			
Radiator Coolant Installed			
Air Purged from Radiator Coolant			
J3 Cable Installed			
J3 Cable Wiring Tested			
Inverter Power Cable Installed			
Inverter Power Polarity Correct			
RS 232 /Modem Cable Installed			
DI Solenoid Cable Installed with Diode			
Natural Gas Pipe Installed			
DI Water / Heat Trace Installed			
Drain Tubing Installed			

Table 2. Commissioning Check List.

Task	Sign	Date	Time (Hrs)
Controls Powered Up and Communication OK			
SARC Name Correct			
Start-Up Initiated			
Coolant Leak Checked			

Flammable Gas Leak Checked			
Data Logging to Central Computer			
System Run for 8 Hours with No Failures			

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SERVICE CALL REPORT **SYSTEM INFORMATION**

System Serial #: Date:

Purpose of Service Call: ☐Repair ☐Maintenance ☐ECN (Check all that apply)

Date Time

Date/Time shutdown

Figure 4. Service Call report.

Maintenance / Repair Information

Service Tech Name: ______________________

Travel Manhours: ______________________

Troubleshooting Manhours: ______________________

Repair Manhours: ______________________

Spare Part Delay Time: ______________________

Work Performed: ______________________

Technician ______________________

Comments: ______________________

FAILURE REPORT SUMMARY

Date	Description of Problem	Rpt #	Initials

Figure 7

LOGANEnergy Corp.

FY' 01 RESSDEM PROGRAM

Ft Bragg PEM Fuel Cell Economic Analysis

Utility Rates	
1) Water (per 1,000 gallons)	$1.69
2) Electricity (per KWH)	$0.0651
3) Natural gas (per MCF)	$5.80

Estimated First Cost	
Plug Power 5 kW SU-1	*$42,500*
Shipping	*$1,000*
Installation electrical	*$4,200*
Installation mechanical	*$2,400*
Watt Meter	*$800*
Site Prep, labor materials	*$925*
Technical Supervision	*$6,500*
Training	*$5,000*
Total	***$63,325***

Assume Five Year Simple Payback @ $12,665 Per Yr.

Forecast Operating Expenses	**Volume**	**$/Hr**	**$/ Yr**

Natural Gas			
Mcf/hr @ 2.5kW	*0.032838*	*$0.19*	*$1,502*
Water			
Gals/Yr	*4918*		*$8.31*

Add Total Annual Operating Costs	**$1,510**
Total Annual Costs (Ammortization + Expenses)	**$14,175**

Economic Summary		
Forecast Annual kWH	*19710*	
Annual Cost of Operating Power Plant	*$0.0766*	kWH
Credit Annual Thermal Recovery	*0*	
Project Net Operating Cost	*$0.0766*	kWH
Amount Available for Financing	*($0.0115)*	kWH
Add 5 Yr Amortization Cost / kWH	*$0.6426*	kWH

Current Demo Program Cost Assuming 5 Yr Simple Payback	**$0.7192**	**kWH**

***NOTE**Does not include allowance for cell stack life cycle costs or service*

over 5 year economic scenario.

Figure 8

Project Contacts

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